Research on the New Structure of Wireless Charging for Electric Vehicles

Guang Yang[1, *], Xiyao Yang [2] and Haowen Zheng [3]

[1] School of Overseas Education, Changzhou University, Changzhou,213164 China
[2] School of Faculty of Mechanical and Materials Engineering, North China University of Technology, Beijing, 100144 China
[3] School of Electrical Engineering and New Energy, China Three Gorges University, Yichang,443002 China
1808010423@stu.hrbust.edu.cn

Abstract. The wireless charging process of electric vehicles often suffers from low charging efficiency and inadequate charging structure, so this paper aims to explore and optimize the charging method of electric vehicles. The article firstly describes the background of wireless charging, and then discuss-es the basic principle of wireless charging and the principle of pressure activation. Then, this paper describes a new wireless car charging design based on the basic principle of wireless charging and pressure activation principle. Among other things, the structure determines the position of the car and controls the switch for charging by means of a notch, and further improves the efficiency of charging by corresponding methods. Through the research of this paper, it aims to further improve the charging efficiency of wireless charging technology in the field of electric vehicle charging, and at the same time builds a more reasonable and advanced charging structure for the wireless charging of automobiles.

Keywords: Wireless Charging; Pressure Activation; Novel Structure.

1 Introduction

In today's prosperous electric power technology, a technology that can transmit electric power to devices without connecting through physical lines, i.e. wireless charging technology, gradually crosses into people's view. Its technical application background is mainly reflected in the following aspects: portable electronic equipment power supply, new energy vehicle power supply, Internet of Things wireless technology applications and industrial manufacturing technology, etc. [1]. Among them, in the field of new energy electric vehicles, the actual widely used charging method is still based on the previous limited charging technology. However, compared with wireless charging, the safety of wired charging is unsatisfactory because there are problems such as line aging, leakage, and water ingress into the cable [2]; and the existing wireless charging technology is mainly based on the electromagnetic induction principle, magnetic field resonance principle, and

Y. Yue (ed.), *Proceedings of the 2024 International Conference on Mechanics, Electronics Engineering and Automation (ICMEEA 2024)*, Advances in Engineering Research 240,
https://doi.org/10.2991/978-94-6463-518-8_63

microwave transmission principle [3]. First of all, for electromagnetic induction technology, wireless charging is mainly applied to small devices such as cell phones and watches; magnetic field resonance technol-ogy is mainly applied to electric vehicles and household appliances and other electrical appliances charging; and finally, the microwave transmission principle is mainly used in the Internet of Things and other fields. Although today's technology can realize wireless charging, there is still the problem of insufficient charging efficiency, and people hope to further improve the charging efficiency in the field of wireless charging for automobiles.

Consequently, electric vehicles will occupy an increasingly important position in the market under the combined effect of the continuous promotion of government policies, the increasing at-tention of consumers to environmentally friendly travel, and the cost reduction and performance enhancement brought about by technological advances, so the wireless charging of electric vehicles has a grand development prospect, but there are still certain problems in its technical implementation. Therefore, this paper aims to solve the charging safety problem of new energy electric vehicles and further improve the wireless charging efficiency of electric vehicles, so this paper designs a new wireless charging structure for electric vehicles based on the wireless charging principle and the pressure activation principle, which can use the pressure activation principle to determine the posi-tion of the electric vehicle and activate the charging device, and at the same time use the wireless charging principle to improve the charging efficiency and safety of the charging device. The wireless charging principle.

2 Electromagnetic Induction and Magnetic Coupling

An automotive wireless charging system consists of two main components: a charging mat and a vehicle receiving device. Using magnetic coupling resonance, a transmitting circuit is set up, i.e., a circuit system consisting of four parts: an AC power supply, a driving circuit (for controlling the current in the transmitting coil and generating an alternating magnetic field), a transmitting coil (a screw coil or a square coil, which can be inductively coupled to the vehicle receiving coil for energy transfer), and a controlling circuit (for monitoring the status of the system and a protection circuit against overloading and short-circuiting), and this device is installed under the ground in the parking space.

At the same time, set a receiving coil consisting of one or more coils under the vehicle, connect the AC power supply to the transmitting coil, let the transmitting coil and the receiving coil resonate (at the resonance frequency, the energy conversion efficiency between the capacitor and the induc-tor is the highest[4], and the current and the voltage in the circuit will reach the maximum, the reso-nance can improve the efficiency of the energy transmission and reduce the energy loss), and set the resonance frequency of the two coils to the the same[5]. The transmitting coil will generate a changing magnetic field when it is energized with AC power, and when the receiving coil with the same res-onant frequency enters the magnetic field, the same frequency magnetic field resonance will be generated between the transmitting and

receiving coils. According to the principle of electromag-netic induction (i.e., when the strength or direction of the magnetic field changes in the conductor, an electric potential (i.e., induced voltage) will be induced in the conductor, thus generating a cur-rent) due to the transmitting coil's periodic changes in the current to produce periodic changes in the magnetic field, so the magnetic field through the receiving coil of the magnetic field strength of the periodic changes in its flux to produce changes in the form of a magnetic field, so that the electrical energy from the transmitting end to the receiving end of the magnetic field to realize Form of cou-pling to the receiving end to realize the transfer of energy, that is, wireless charging[6].

The essence of the pressure activation principle is to bury four force-sensitive resistors under the four wheel positions in the parking space, which are connected to the wireless charging sole-noids under the parking space to form a series circuit and power supply using AC power. Force sen-sitive resistor resistivity with its pressure increases and decreases, when the pressure is approximate-ly zero when the resistivity is great, the resistance value is great, according to Ohm's law, when the resistance value of the circuit is great, due to the AC power supply potential is unchanged so that the current in the circuit is extremely small, in practice can be considered as zero, that is, negligible, so this time the series circuit can be considered as a circuit breaker. Due to the disconnection of the AC power supply can not power supply for the transmitter coil, so the transmitter coil can not pro-duce periodic changes in the current, the magnetic field does not exist periodic changes, so the re-ceiver coil can not be produced because of the transmitter coil magnetic field produces periodic changes in the magnetic flux changes in the field of the magnetic coupling of the electric energy for the charging of the car. When and only when the four piezoresistors are all stressed and the pressure is large enough, the circuit is converted to a path AC power supply can continue to power the transmitting coil, according to the principle of wireless charging , principle of electromagnetic in-duction, it can be seen that at this time it is possible to complete the magnetic coupling of electric energy, to realize the conversion of electric energy, to achieve the purpose of wireless charging for the car[7].

3 Structure

The design of electric vehicle wireless charging structure involves several key parts, and the main purpose is to achieve high and safe wireless transmission of electric energy. Wireless charging tech-nology is based on the principles of electromagnetic induction and magnetic field resonance to achieve wireless transmission of electric energy. In electric vehicle wireless charging, electromagnet-ic induction is usually used for energy transmission. The basic principle is that an alternating mag-netic field is generated at the transmitting end by a high-frequency current, and the receiving end charges the electric vehicle by the current generated by induction. [8]

As shown in Fig. 1 the total structure of the car wireless charging is divided into above ground structure, ground structure and underground structure. Firstly the above

ground structure is de-signed for the alignment between the coils. The design of the coils is one of the main focuses of the whole structure, the static tram wireless charging system has no restriction on the main coupler, however, as the coupler is located in the chassis of the car, the driver of the car can cause the coils to deflect when he stops the car. So four depressions are designed on the ground, (Figure 2) these four depressions are just enough to park the four tyres of the car , these four depressions allow better po-sitioning of the car, so that the deviation between the coils is narrowed down, thus maximizing the magnetic flux passing through the two coils, and the driver can judge the exact position based on whether or not he has parked his car into the depressions. To make charging more efficient. We have connected a force sensitive resistor in series in front of the coil, only when the four tyres of the car are completely parked in the depression the resistance value of the force sensitive resistor becomes the minimum, the wireless charging system will be energised to the car battery, considering the limi-tation of the driver's parking technique, the width of the depression is about 1.5 times of the tyre, and the depth is 20cm, this design also makes the distance between the two coils closer, the medium between the two coils will also become less, the transmission efficiency is higher[9]. Transmission efficiency is higher. The general weight of the car is 800kg-1200kg, so the critical value of the pres-sure sensor is designed as 8000000N. This design can improve the accuracy of the two coils in the car and the underground, and will not cause the coil to deflect too much due to the driver's parking technology, which can effectively improve the efficiency of the wireless charging of the electric ve-hicle, in addition to the series connection in the transmitter side of the four force-sensitive resistors play two roles, one is as a kind of tip. One is that it can be used as a kind of prompt. When the driv-er accurately parks the electric car into the position, the resistance value of the force-sensitive resis-tor of the circuit becomes small, the circuit starts to be energised, and the mutual inductance be-tween the two coils starts to charge the car's battery, so the driver can get the news that the car starts to charge, and the second is to protect the circuit, when the pressure above the four notches is too small, the resistance value of the four force-sensitive resistors will be very large circuit is equiva-lent to a short-circuit, so that it can prevent pedestrians next to the parking place from electrocution and other dangerous Accidents

The entire wireless charging of electric vehicles using the principle of magnetic coupling reso-nance, this technology mainly consists of two resonant circuits with the same frequency, respective-ly, for the transmitting end and receiving end, the power from the power supply end of the wireless transmission to the battery of the electric vehicle. Magnetic coupling resonance technology is suita-ble for medium-distance transmission, and the charging efficiency is also improved on the basis of increased transmission distance. The transmitting and receiving ends of the magnetic coupling reso-nance are divided into the underground structure and the in-vehicle structure, with the underground structure as the transmitting end and the in-vehicle structure as the receiving end, and the transmit-ting end consists of a resonant coil and a power module. The power supply module provides a high frequency current to excite the resonant coil to generate a high frequency magnetic field. The trans-mitting end usually includes a control circuit to regulate parameters such as output power and fre-

quency. The receiving end contains a resonant coil and rectification and filtering circuits. The reso-nant coil receives the high-frequency magnetic field from the transmitter and converts the energy into electrical energy. The rectifier and filter circuit converts the received AC signal into DC for charging or power supply. The above ground structure is composed of the circuit inside the car which consists of the coil, the LC compensation circuit, the rectifier circuit and the power supply connected in sequence, in which the coil part should be placed at the bottom of the car to reduce the medium between the two coils and improve the charging efficiency. The underground structure consists of an underground structure consisting of a rectifier circuit, a high-frequency inverter circuit, an LC compensation circuit and a coil connected in sequence and a four resistors controlled by pressure sensors are connected in series between the coil and the LC oscillator circuit and a portion of the ground above the coil is paved with a material with high magnetic permeability, which in-creases the magnetic flux through the coil. In an ideal situation, the AC power provided by the power grid is changed into regulated DC power by a rectifier circuit, and then converted into high-frequency AC power by a high-frequency inverter circuit, and then the power supply to the transmitting coil is realised under the action of the LC compensation circuit, so that the transmitting coil generates an electromagnetic field. [10] As the receiving end of the vehicle structure receiving end through the LC compensation circuit to adjust the receiving coil resonance frequency adjust-ment and the same as the transmitting end, so that the transmitting coil and the receiving coil is in a state of resonance, after the rectifier circuit is converted into a regulated DC, so as to realise the charging to the car. The advantage of such wireless charging is that the user does not need to manu-ally unplug the charging head, reducing the complexity of the work, coupled with the structure of the entire charging without exposed wires, which makes the charging of the security is greatly en-hanced, charging is more secure.

In the selection of the coil, the Leeds wire-wound planar spiral coil not only has a strong over-current capability, but also shows higher transmission efficiency and lower energy loss in the high frequency environment. This design can effectively reduce attenuation during signal transmission and improve signal stability and reliability. In addition, the Leeds wire-wound planar helical coil is more compact in structure and occupies less space, making it suitable for applications where space is limited, allowing for more flexible layout and installation. Taking into account factors such as power consumption, performance and space utilisation, Leeds wire-wound planar helical coils are an excel-lent design choice. In summary, the Leeds wire-wound planar helical coil design has strong current capability and high transmission efficiency in wireless energy transmission systems, and the fre-quency of the system has an important impact on the output power and transmission efficiency, while the relative attitude of the transmitting coil also significantly affects the transmission effi-ciency.

4 Design Philosophy

In order to give users a faster and more convenient experience for parking and charging, this structure adopts the magnetic coupling resonance wireless charging mode, this method can be suitable for medium-distance transmission and higher charging efficiency. This structure is different from the ordinary magnetic coupling resonance wireless charging is that this structure in the magnetic coupling on the basis of an additional set of positioning system, the use of pressure sensors and force sensitive resistors to control the current size of the transmitting end of the circuit, this design not only allows the user to save the parking position of the inaccurate troubles can also improve the efficiency of the wireless charging of electric vehicles.

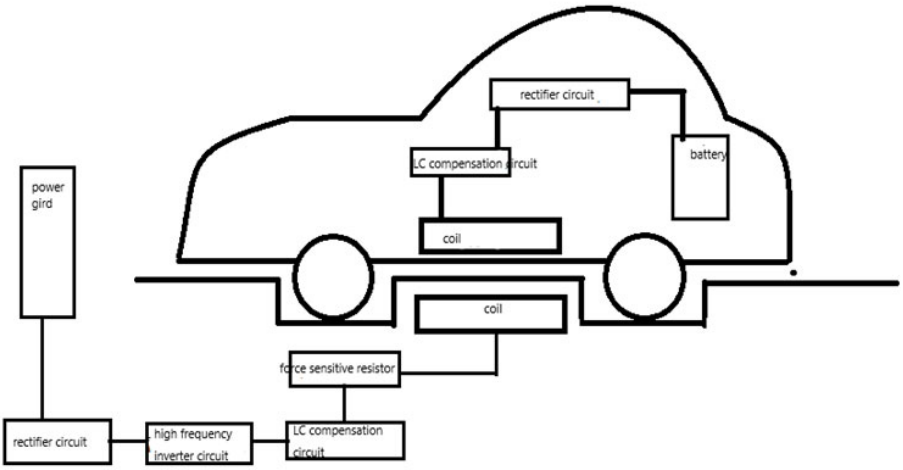

Figure.1. Overall structure

Photo/Picture credit : Original

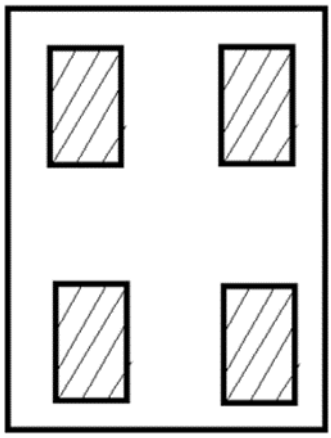

Figure 2. Ground structure

Photo/Picture credit : Original

5 Conclusion

Firstly, a series of literature and related news reports were read to make a preliminary understanding of the current use of electric vehicles, development prospects and current problems, and to recognize some of the current problems of electric vehicle charging. Secondly, the charging principle of electric vehicles was explored, in which the wireless charging principle and pressure activation principle were mainly studied and used as the basis for designing the structure. Finally, a safer and more efficient charging structure is designed based on these principles.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

1. Ye, Y.: Principles and Applications of Wireless Charging Technology. Guangdong University of Technology (2023)
2. Tian, Z.: Research on safety and privacy issues in dynamic charging systems for electric vehicles. University of Science and Technology of China (2024)
3. Chao, Z., Zhe, W., Quan, Li.; et al.: Research status and development trend of wireless charging technology for pure electric vehicles. Hunan Automotive Engineering Vocational College (2023)
4. Fang, F.: Research on power load forecasting based on Improved BP neural network. Harbin Institute of Technology (2011)

5. Cheng, Q., Sun, C., Zhang, X.: Short-Term load forecasting model and method for power system based on complementation of neural network and fuzzy logic. Transactions of China Electrotechnical Society 19(10), 53-58 (2004)
6. Amjady, N.: Short-term hourly load forecasting using time series modeling with peak load estimation capability. IEEE Transactions on Power Systems 16(4), 798-805 (2001)
7. Ma, K.: Short term distributed load forecasting method based on big data. Changsha: Hunan University (2014)
8. Yue, Q., Lü, H., Wang, Y., Li, J. : Analysis of Wireless Charging Technology for Electric Vehicles, China Auto Information Technology (2022)
9. Yu, Y., Li, M.: An Ziqi Research on Magnetic Coupling Resonance and Induction Coupling Electric Vehicle Charging System (2023)
10. Wang, X., Zhao, W., Wei, J.: Magnetic coupling resonant wireless charging technology for electric vehicles Coupling coil anti-bias design (2024)